Flame Test Lab

Background:

By placing atoms of a metal into a flame, electrons can be induced to absorb energy and jump to an excited energy state, a quantum jump. They then return to their ground state by emitting a photon of light (the law of conservation of energy indicates that the photon emitted will contain the same amount of energy as that absorbed in the quantum jump). The amount of energy in the photon determines its color; red for the lowest energy visible light, increasing energy through the rainbow of orange yellow green blue indigo, and finally violet for the highest energy visible light. Photons outside the visible spectrum may also be emitted, but we cannot see them.

The arrangement of electrons in an atom determines the sizes of the quantum jumps, and thus the energy and colors of the collection of photons emitted, known as emission spectrum. In this way the emission spectrum serves as a 'fingerprint' of the element to which the atoms belong. We can view the emission spectrum of colors all at once with the naked eye. It will appear to be one color, which we will carefully describe. It is also possible to view the separate colors of the emission spectrum by using a spectroscope, which bends light of different energies differently. Low energy red light is bent the most and high energy violet the least. This allows us to see the various distinct colors of the emission spectrum of a sample.

In this lab we will record the flame test color of several metals by capturing droplets of solutions of salts, or ionic compounds of those metals with a platinum wire loop, then placing the loop into a Bunsen burner flame. We will attempt to use spectroscopes to view the separate colors of the emission spectra, but this is difficult to do under our lab conditions because the flame test is of short duration and the lab lights will be dimmed to better see the flames. We will also compare the flame tests of crystals of a compound (NaCl) with that of a solution of the same compound.

Cobalt blue glass filters are often used when viewing mixtures of metals to screen out light that is yellow in color. The human eye sees yellow very well, since it is in the middle of the spectrum visible to the eye. Colors at the edges of the visible spectrum, especially violet, are more difficult to see. Cobalt glass absorbs light in the yellow wavelengths, but is transparent to light of higher energy (this is why it looks blue!). Viewing a yellow flame through cobalt glass will allow us to see if there is any higher energy light present.

Finally, we will use the data we collect to identify a metal in an unknown salt solution. This process is similar to that used by chemical laboratories to identify the make-up of chemical contamination in chemical spills, landfills, industrial sites, etc. This must be done to determine the possible threat to human health and the ecosystem due to contamination.

Safety: Cautions should be taken not to burn one's self in a flame

Pre-lab Questions:

1. What color of light is lowest in energy? What is highest?
2. What is the purpose of a spectroscope?
3. Before we begin each flame test we will clean the wire loops with 1.0 M HCl several times. Why is it essential that the wire loop be clean?
4. How can cobalt blue glass help us to see violet and blue light?
5. If you test two samples and find that both produce a red flame, how can you determine for sure whether they contain the same metal?
6. Most salts contain a metal and a non-metal. Look at the compounds we will test and determine how we can be sure that it is the metal atoms that emit the photons and not the non-metal.

Procedure:

1. On a separate sheet of paper, create a data table with 6 columns and 14 rows. Label the 3rd, 4th and 5th boxes of the first row, Trial 1, Trial 2, Trial 3. Label the ***SECOND*** row as follows (in order): metal compound, color of flame, wavelength (nm), wavelength (nm), wavelength (nm), summary. Label the first column (starting with the 3rd row): $CaCl_2$ solution, K_2SO_4 solution, Li_2SO_4 solution, Na_2SO_4 solution, $SrCl_2$ solution, NaCl solution, NaCl crystals, Na_2SO_4 (cobalt glass), K_2SO_4 (cobalt glass), Na_2SO_4 and K_2SO_4, Na_2SO_4 and K_2SO_4 (cobalt glass), Unknown solution. Add two more rows for $CuSO_4$ and $NiCl_2$.

2. Look at the beakers on your lab bench. Be sure you have correctly identified each and matched it to the correct row in your data table.

3. Obtain and light a Bunsen burner.

4. **Basic Flame Test Procedures:**
   a. Clean metal loop on the flame test wire with DI water.
   b. Dip the wire into the test solution to capture a droplet of solution.
   c. Hold the wire loop in the flame for a few seconds and record your results in the data table.
   d. Repeat the flame test while attempting to view the flame with the spectroscope (2x so each partner may see) and record the colors of any bright lines you see.
   e. Tidy the station then move on to the next.

5. Obtain a spectroscope. One person should look at the flame through the spectroscope while the other holds the wooden splint in the fire. Use the same splint as before. Record the bright lines evident.

6. Repeat step 5, switching places (Move to a new lab bench).

7. If the data is different in step 5 and 6, do the procedure a third time.
8. Obtain a cobalt glass square. Test the solution in the flame, looking at the flame through the cobalt glass. Repeat so both partners can observe. Record your observations. NOTE: you will ***not*** use the spectroscope for this procedure, so you will not fill in the wavelength portion of the data table.

9. Repeat steps 4-8 using the $CaCl_2$, K_2SO_4 solution, Li_2SO_4 solution, Na_2SO_4 solution, $SrCl_2$ solution, and NaCl solution (Go to appropriate station).

10. NaCl Station: Wet an inoculating loop in distilled water, and place it in the NaCl crystals to get some to stick. Hold the NaCl crystals in the flame and record your observations. NOTE: you will not use the spectroscope for this procedure, so you will not fill in the wavelength portion of the data table.

11. Using your knowledge gained through these procedures, test the unknown solution. Record your data.

Clean Up

Leave Bunsen burners, strikers, and the solutions on your lab bench.
Return remaining items to their place on the bench.
Put all used wood splints into the waste beaker on the hood.

Wash your hands before returning to your seat.

Questions:

1. Examine your data table, and create a summary for the flame tests for each metal ion. Write this summary in the correct place in your data table.

2. Explain how viewing the flame under the cobalt glass can make it easier to analyze the ion being tested.

3. Explain how the lines seen in the spectroscope relate to the position of electrons in the metal atom.

4. What metal ion is in your unknown solution? How do you know?

5. How sensitive is the flame test? Could it be used to accurately identify metal ions? What difficulty could there be when identifying ions by the flame test.

6. Explain how you could use a spectroscope to identify the components of a solution with several different metal ions in it.

7. A student performed a flame test on several unknowns and observed that they all were shades of red. What should the student do to correctly identify these substances? Explain your answer.

8. Fireworks come in a variety of color. Explain how the fireworks manufacturers could get these colors.

Materials
Crayon/ colored pencils
Spectroscopes
Inoculation rings
Make all in 150ml beaker, ~0.5g/ 50mL DI water
Label beakers

1. $CaCl_2$ solution,
2. K_2SO_4 solution,
3. Li_2SO_4 solution,
4. Na_2SO_4 solution,
5. $SrCl_2$ solution,
6. NaCl solution,
7. NaCl crystals,
8. Na_2SO_4 and K_2SO_4,.

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